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RESEARCH ARTICLE

Study on the relict flora of Lozenska Mountain

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Abstract

The purpose of this study is to make an inventory of the relicts in the flora of Lozenska Mt., to clarify their origin, taxonomical, ecological and phytogeographical structure and to evaluate their role for the formation of the contemporary flora and vegetation, economic uses and measures for their conservation. The study was conducted in the period 2017-2019. In order to cover the maximum area and different ecological niches, the sampling was conducted using the transect method. The surveyed territory and its two geographic regions, north-west and south-east, were divided into four sub regions (parts) and 19 transects were used for possible comparisons. The biology and ecology of the relict plants was made, thus allowing to group the species in biological and ecological groups, based on life forms, floristic and phytogeographical elements, synanthropy and economic uses. As a result, 61 species and three subspecies, belonging to 48 genera and 35 families, were identified as relict taxa. These number represent 7.4% of the whole flora of Lozenska Mt. (823 species) and 17.6% of the relict species in Bulgarian flora. Tertiary were 93.4% of the mountain's relicts. The families with the richest number of relict species were Salicaceae (9 species) and Ranunculaceae (4 species). The genera with the largest number of relict species were *Salix* (5 species) and *Populus* (4 species). The most relicts (73.7% from their total number on the territory of the mountain) were registered in the south-west part of the mountain, while the smallest number (52.5%) was found in its north-east and south-east parts. The phanerophytes (dominated by the threes) prevailed with more than 60%, followed by the hemicryptophytes (16.4%) and geophytes (13.1%). Most of the relicts on the territory of the Lozenska Mt. have Euroasiatic (17.7%) and sub-Mediterranean (17.7%) origin. The established relicts are predominantly heliophytes (61.3%), mesotherms (86.9%) and mesophytes (59.0%). Each of the studied species is a plant with economic benefits: forestry (36.1%), non-wood resources (88.5%) or ornamental uses (54.1%). *Salix caprea* and *Polygonatum odoratum* are included in the Bulgarian Biodiversity Act (2002). The other relict species fall under provisions of different laws, such as the Medicinal plants Act, Forestry Act, Biodiversity Act, including NATURA 2000 legislative base.

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Keywords
forest, plants, refugia, phanerophytes, hemisciophytes, mesophytes, thermophytes.

Introduction

The study of the relict plant species on a certain territory contributes toward information about the origin, distribution and dynamics of its flora. The survived relicts help assess the autochthony of the flora and are the base of taxonomic and geographical patterns of biodiversity (Cronk, 1992). They are an indicator of the extent of ongoing and currently evolving processes. The Tertiary relict floras are notable for exhibiting slow morphological evolution (stasis). This might result from large-scale allopatric speciation, together with stabilising selection (Milne, Abbott, 2002). The studies of the relicts in Bulgaria make it possible to identify the status of their populations and carry out activities to preserve them as an important part of the country's biodiversity (Hristova et al., 2015).

Historical and contemporary geography and environment have been affecting the distribution, genetic diversity, lineage divergence and speciation of the Tertiary relict plants. (Yingxiong Qiu et al., 2017). The present flora of Bulgaria is genetically related to the flora of the Pliocene and Pleistocene periods. Our country, similarly to the rest of South-Eastern Europe, is a region in which the pre-glacial flora was well preserved; many species of which have migrated northwards and contributed to the present flora of Central Europe. The change in the climate toward greater aridity together with various human activities (deforestation, drainage, pasturing, agriculture) have been very important factors in determining the present flora of Bulgaria (Kuzmanov, 1969).

The soil properties influence forest productivity and vegetation development. Generally, the sandy soils contain less moisture and nutrient elements in comparison with the loam and clay soils. Thus, coarse sandy soils as a rule favour forest stands composed of species with relatively low requirements for moisture and nutrients, whereas loam and clay soils often are favourable for species with high moisture and nutrient requirements (Bogdanov, 2012).

The comparison between modern floristic studies of surviving relicts and paleobotanical studies, conducted within the same territory, is very important in terms of ensuring continuity in the monitoring of changes in the vegetation cover and the factors and processes that determine it. An example of that kind of territory is the current object of study. The Lozenska Mt. (its north-east part in particular, where the Chukurovo Lignite Basin is located), has been extensively studied by paleobotanists during the last 50 years. More information about the vegetation of the mountain through the Tertiary is presented by Palamarev (1964, 1989a) and Palamarev (1971). The laurel communities originating from the subtropics, prevailed on its territory. In addition, the main plant type belonged to moderately warm, evergreen deciduous forests that were characterised by the transitional nature of the typical

hygrophytic laurel forests, to mixed mesohygrophytic and mesophytic forest communities (Palamarev, 1989a). Palamarev, Ivanov (2004) found a slight tendency of a decrease in the thermophilic elements in the communities at the end of the Badedian stage of Middle Myocene (Hohenegger at al., 2014) and an increase of the Arctic floristic elements.

Until now, the relicts in the contemporary flora of Lozenska Mt. have not been a subject of an independent study. General information about their presence on the territory of the mountain is presented by Glogov, Delkov (2016), who identified 32 relict species (3.5% of the flora of the mountain), 31 of them were Tertiary and 1 was a Quaternary relicts. Subsequently, other publications (Glogov, 2017; Glogov, Pavlova, 2018) recorded more relicts in the mountain's flora.

The purpose of this study is to make an inventory of the relicts in the flora of Lozenska Mt., to clarify their origin, taxonomical, ecological and phytogeographical structure and to evaluate their role for the formation of the contemporary flora and vegetation, economic uses and measures for their conservation.

Materials and Methods

The Lozenska Mt. is a part of the Sredna Gora floristic region. A string of peaks at an altitude of 985–1190 m a.s.l. forms the main ridge with an east-west orientation. The mountain falls into the Transitional Climate Zone which is characterised by relatively mild winters, low annual temperature amplitudes and two maxima of annual rainfall (Velev, 1997). The predominant soil types are cinnamonic forest soils (Chromic Luvisols) and brown forest soils (Dystric-Eutric Cambisols). Cinnamonic forest soils, containing higher amount of clay and moisture, are situated in the area of the xerothermic oaks. Brown forest soils occur in the area of the beech forests. They are loam or sandy and their properties depend on relief influence (Ninov, 1997; Bogdanov, 2018).

Part of the mountain area (12944.2 dka) has the status of BG0000165 Protected Area under Directive 92/43 / EEC for the Conservation of Natural Habitats and Wild Flora and Fauna, adopted through the Council of Ministers Decision No. 122 / 02.03.2007. Its area, according to the NATURA 2000 Standard Form, is 12944.2 dka (Glogov, 2017). Subject to preservation in the area are 12 natural habitats, four of which are with priority. In the present study, the Manual for identification of habitats of European conservation significance (Kavrakova et al. 2005) was used for the determination of the characteristic species in different NATURA 2000 habitats. The study was conducted in the period 2017-2019.

The transect method was applied for the fieldwork in order to cover the maximum area and different ecological niches. The surveyed territory and its two geographic regions, north-west and south-east (Danov, 1964) were divided into four subregions (parts) and namely: north-west (Part I), north-east (Part II), south-west (Part III) and south-east (Part IV). Moreover, we sampled 19 transects on the terri-

tory of the mountain , thus ensuring reliable comparisons (Fig. 1). The same transects were used in the parallel study of medicinal (Glogov, Pavlova, 2018) and anthropophitic flora (Glogov et al., 2019) of the Lozenska Mt. Part of the species data used are included in the Joint Database developed within project №CB007.2.32.170 "For everyone saved a tree" (FOREST), co-funded by EU through the Interreg-IPA CBC Bulgaria–Serbia Programme 2014 – 2020.

The taxonomical nomenclature, life forms and biological types of the plants followed Delipavlov, Cheshmedzhiev (2003). Relicts were classified according to Kuzmanov (1969, 1976); Palamarev at al. (2005); Bozukov, Tsenov (2012); Zahariev (2016); Zahariev et al. (2018). Other species groups were determined as follows: floristic elements (Asyov, Petrova, 2012), phytogeographic elements (Stefanoff, 1943), ecological groups (Pavlov, 1998; Glogov, Delkov, 2016), anthropophytes (Stefanoff, Kitanov, 1962; Petrova, Vladimirov, 2001; Glogov et al., 2019). The conservation status of the species was established based on national and European documents. The economic uses of the relicts were assessed according to Yanev (1959), Delkov (1988), Zahariev et al. (2018).

The distribution of each group is presented in separate table with abbreviations, according to the following legend: *Relicts*: *TR*- Tertiary relict; *QR*- Quaternary relicts; *Biological types*: *1*- annual, *2*- biennial; *3*- perennial; *4*- semi-shrubs; *5*- shrubs; *6*- trees; *Life forms*: *H*- hemicryptophytes; *G*- geophytes; *Ch*- chamaephytes; *Th*- therophytes; *Ph*- phanerophytes; *Hl*- helophytes; *Floristic elements*: *Eur*- European, *As*- Asian, *Med*- Mediterranean, *SubMed*- Sub-Mediterranean, *OT*- Oriental- Turanian, *Sib*- Siberian, *Ap*- Apennine, *Carp*- Carpathian, *Bal*- Balkan, *Kos*- cosmopolitan; *C*- central; *Phytogeographic elements*: *TSCC*- Thermophytes from the southern continental centre; *TNCC*- Thermophytes from the northern continental centre;

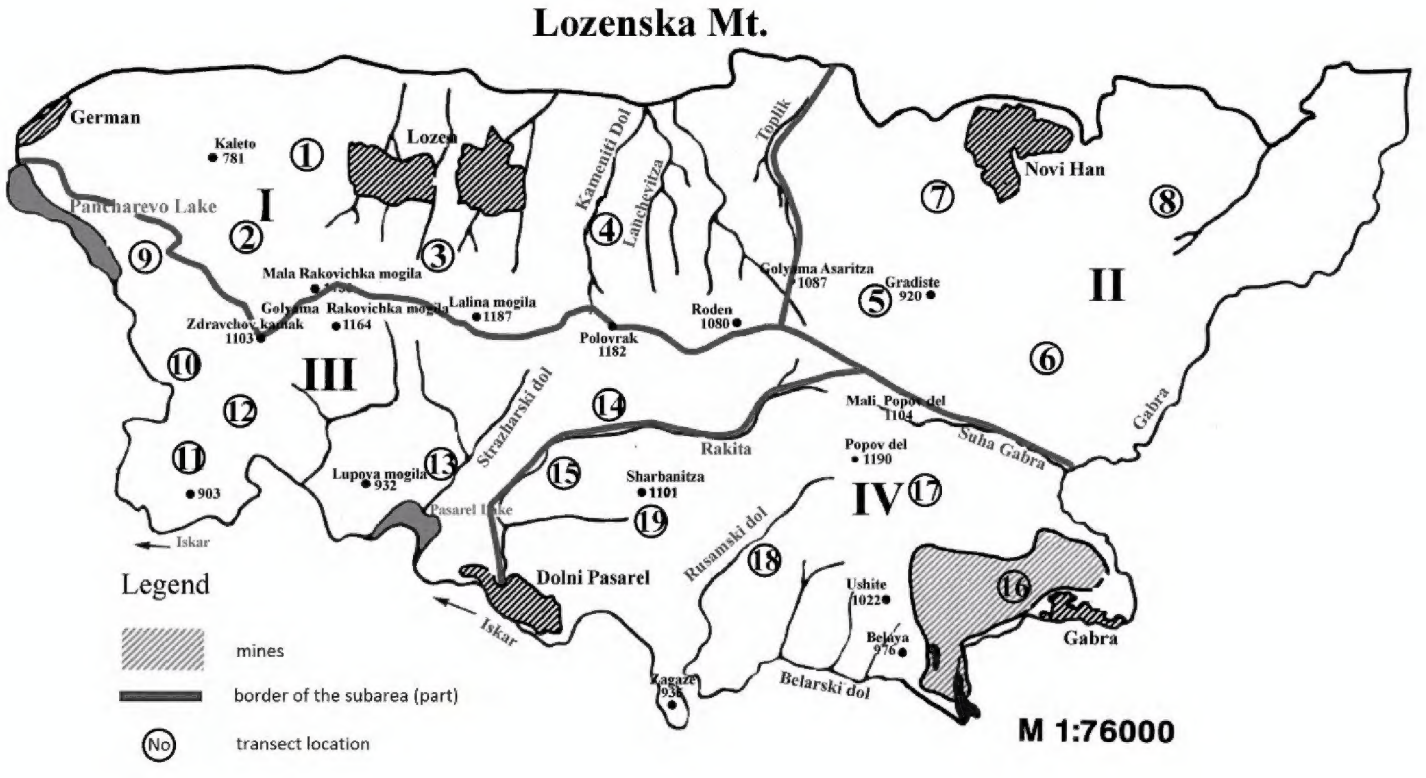

Figure 1. Map of the Lozenska Mt. with regions and transects

TMC- Thermophytes from the Mediterranean centre; *TMMM*- Thermophytes, mesotherms and microtherms from the mountaineous centre; *MSBC* - mesotherms and microtherms from the silvoboreal centre; *1*- stationary species; *2*- mobile species; *II*- plants with secondary extended ranges; *Ecological groups* in terms of: *Light-factor*: *He*- Heliophytes; *Sc*- Sciophytes; *Sh*- Hemisciophytes; *Soil humidity*: *Hl*- Helophytes, *Hm*- Hygromesophytes; *Mf*- Mesophytes; *Xm*- Xeromesophytes; *Mx*- Mesoxerophytes; *Xe*- Xerophytes; *Temperature*: *Mic*- Microtherms; *Mez*- Mesotherms; *XeFl*- Xerophiles; *HyMeg*- Hydromegatherms; *Synantropic* groups: *Av*- Autohtonic species, *Ap*- Apophytes, *At*- Anthropophytes;

Results

As a result of the study, 61 species and three subspecies belonging to 48 genera and 35 families were identified (Table 1). This number represents 7.4% of the whole flora of the Lozenska Mt. or 823 species (Glogov, 2017) and 17.6% of the relict species in Bulgarian flora or 346 species (Zahariev, 2016). The established species belonged mainly to the group of the Tertiary relicts. They were represented by 57 species or 93.4% of the mountain plant relicts and 31.1% of the Tertiary plant relicts recorded in Bulgaria. We found four Quaternary relicts, which corresponded to 6.6% of all mountain relicts and 2.5% of the Quaternary relicts of the Bulgarian flora (Zahariev, 2016).

The percentage of the relicts in the flora of the Lozenska Mt. (7.4%) was lower than the total participation of relicts in the flora of Bulgaria (8.7%). Therefore, their presence on the territory of the mountain could not be estimated as high. The mountain itself is a part of the main corridors of species distribution, as it is clear from the data on the floristic and phytogeographic elements (Tables 3 and 4). Evidence of the noticeable presence of relicts on the territory of the Lozenska Mt. is found in the comparison of the present data with the results of floristic studies of similar geographic areas and mountains with comparable altitudes (Table 2). We recorded almost twice as much relicts on the territory of the Lozenska Mt. as compared to their number established by Glogov, Delkov (2016).

The taxonomical structure of the relict flora of Lozenska Mt. is presented in Table 3. The established relicts are representatives of Equisetophyta - 1 species (1.6% of the relicts), Polypodiophyta - 1 species (1.6%), Pinophyta - 5 species (8.2%) and Magnoliophyta - 54 species (86.6%). The species of Magnoliopsida (80.3%) dominated over the species of Liliopsida (8.2%). Between the families with the highest number of species is Salicaceae (9) and Ranunculaceae (4). The genera with the largest number of relict species are *Salix* (5 species) and *Populus* (4 species).

The highest number of recorded relicts (73.7%) from all the territory of the mountain were registered in its south-west part, while the smallest number (52.5%) was found in its north-eastern and south-east parts. 32.8% of the relicts were present in all parts; 6.6% in only three of the the parts and 5.0% in only two of the

Table 1. List of taxa of the vascular relict flora established on the territory of the Lozenska Mt.

№	Taxa	Biological types	Life forms	Floristic elements	Origin	Phytogeographical elements	Ecological groups			Synantropic groups	Part of the mountain with transects (No)				Uses		
							Light	Soil humidity	Temperature		Part 1	Part 2	Part 3	Part 4	Forestry	Non wood forest products	Decorative
	Equisetaceae																
1	*Equisetum palustre* L.	3	Hl	Boreal	TR	2TNCC	He	Hl	Mez	At				16,18		V	
POLYPODIOPHYTA																	
	Hypolepidaceae															V	
2	*Pteridium aquilinum* (L.) Kuhn	3	G	Kos	TR	IITMC	He	Mf	Mez	At	1,2,3,4	5,7,8	9,10,13,14	16,17,19		V	
PINOPHYTA																	
	Cupressaceae																
3	*Juniperus communis* L.	5,6	Ph	SubBoreal	TR	1MSBC	He	Mx	Mez	Ap	1,2,4	5,7,8	9,10,12,13,14	15,16,17,19		V	V
4	*Juniperus oxycedrus* L.	5,6	Ph	SubMed	TR	1TMC	He	Xe	HyMeg	Ap	3					V	V
	Pinaceae																
5	*Picea abies* (L.) Karst.	6	Ph	Boreal	TR	1MSBC	Sc	Mf	Mic	Av	4				V	V	V
6	*Pinus nigra* Arnold	6	Ph	SubMed	TR	1 TMMM	He	Mf	Mez	Av	1,2,3,4	5,6,7,8	9,10,11,12,13,14	15,16,17,18,19	V	V	V
7	*Pinus sylvestris* L.	6	Ph	SubBoreal	TR	1MSBC	He	Mf	Mic	Av	1,2,3,4	5,6,7,8	9,10,11,1213,14	15,16,17,18,19	V	V	V
MAGNOLIOPHYTA																	
Magnoliopsida																	
	Aceraceae																
8	*Acer platanoides* L.	6	Ph	SubMed	TR	1MSBC	Sh	Mf	Mez	Av	1,2,4,	5,7,8,	9,10,11, 12,13	16,17,19	V	V	V
9	*Acer pseudoplatanus* L.	6	Ph	Eur-Med	TR	1TMMM	Sh	Xm	Mez	Av	1,2,4,	5,7,8,	9,10,11, 12,13	16,17,19	V	V	V
10	*Acer tataricum* L.	5,6	Ph	SubMed	TR	1TNCC	Sc	Mf	Mez	Ap	1,4	5,7	9,10,12	17,19	V	V	V

№	Taxa	Biological types	Life forms	Floristic elements	Origin	Phytogeographical elements	Ecological groups			Synantropic groups	Part of the mountain with transects (No)				Uses		
							Light	Soil humidity	Temperature		Part 1	Part 2	Part 3	Part 4	Forestry	Non wood forest products	Decorative
	Anacardiaceae																
11	*Cotinus coggygria* Scop.	5	Ph	Med-As	TR	1TMMM	Sh	Mx	Xefl	Av			10		V	V	
	Apiaceae																
12	*Sanicula europaea* L.	3	H	Eur-Sib	TR	1MSBC	Sc	Mf	Mez	Av	1,2,4			17		V	
	Araliaceae																
13	*Hedera helix* L.	5	Ph	Eur-As	TR	1TMMM	Sh	Mf	Mez	Ap	1,2,4	5,8	9,10,11,12	17		V	V
	Aristolochiaceae																
14	*Asarum europaeum* L.	3	G	Eur-As	TR	1MSBC	Sc	Mf	Mez	Av	1					V	
	Asteraceae																
15	*Mycelis muralis* (L.) Dum.	1	Th	Eur-Med	TR	1TMMM	He	Mf	Mez	Av	1,2,4,		9,10,12,1314	17			
	Berberidaceae																
16	*Berberis vulgaris* L.	5	Ph	Eur-Med	TR	IITSCC	He	Mf	Mez	Ap			16			V	V
	Betulaceae																
17	*Alnus glutinosa* (L.) Gaertn.	6	Ph	Med-CAs	TR	1MSBC	He	Hm	Mez	Av		7,8	11		V	V	
18	*Betula pendula* Roth	6	Ph	Eur-Sib	TR	1MSBC	He	Mf	Mez	Ap	1,4	5,7	9,10,12,14	17,19	V	V	V
	Caprifoliaceae																
19	*Lonicera xylosteum* L.	5	Ph	Eur-Sib	TR	1MSBC	Sh	Mf	Mez	Ap			12	19		V	V
20	*Viburnum lantana* L.	5	Ph	Eur-Med	TR	1TMMM	He	Mf	Mez	Av	1,2		9,14		V	V	V
	Cariophyllaceae																

№	Taxa	Biological types	Life forms	Floristic elements	Origin	Phytogeographical elements	Ecological groups			Synantropic groups	Part of the mountain with transects (No)				Uses		
							Light	Soil humidity	Temperature		Part 1	Part 2	Part 3	Part 4	Forestry	Non wood forest products	Decorative
21	*Dianthus giganteus* D'Urv. subsp. *giganteus*	3	H	SubMed	TR	1TMMM	He	Xm	Mez	Av	5	11,1	19				V
	Chenopodiaceae																
22	*Chenopodium album* L.	1	Th	Kos	TR	IITSCC	He	Mf	Mez	At	1,4	6,8	13			V	
	Corylaceae																
23	*CarPinus betulus* L.	6	Ph	Eur-subMed	TR	1TMMM	Sc	Mf	Mez	Av	1,2,3,4	5,7,8	9,10,11,1213 14	17,19	V	V	
24	*CarPinus orientalis* Mill.	6	Ph	SubMed	TR	1TMMM	He	Xm	Xefl	Ap	1,2,3,4	5,6,7,8	9,10,11,1213, 14	15,16,17 18,19	V	V	
25	*Corylus avellana* L.	5	Ph	Med-CAs	TR	1MSBC	Sh	Xm	Mez	Av	1,2,3,4	5,6,7,8	9,10,11,1213 14	15,16,17 18,19		V	
	Cornaceae																
26	*Cornus mas* L.	5и6	Ph	SubMed	TR	1TMMM	He	Xm	Mez	Ap	1,2,4	5	9,12	17		V	
	Ericaceae																
27	*Vaccinium myrtillus* L.	5	Ph	Boreal	TR	1MSBC	Sc	Mf	Mez	Av	4					V	
	Fabaceae																
28	*Colutea arborescens* L.	5	Ph	SubMed	TR	2TMMM	He	Mf	Mez	Ap	2						V
29	*Medicago lupulina* L.	1и3	Th-H	Eur-As	TR	IITSCC	He	Xm	Mez	At	1,2	6	14	17,18		V	
	Fagaceae																
30	*Quercus cerris*	6	Ph	Euro-subMed	TR	1TMMM	He	Xm	Mez	Av	1,2,3,4	5,7,8	9,10,11,1213, 14	15,17,18 19	V		
	Lamiaceae																
31	*Lycopus europaeus* L.	3	H	Eur-As	TR	1MSBC	He	Mf	Mez	Av				19		V	

№	Taxa	Biological types	Life forms	Floristic elements	Origin	Phytogeographical elements	Ecological groups			Synantropic groups	Part of the mountain with transects (No)				Uses		
							Light	Soil humidity	Temperature		Part 1	Part 2	Part 3	Part 4	Forestry	Non wood forest products	Decorative
32	*Lamiastrum galeobdolon* (L.) Ehrend. & Polaschek subsp. *galeobdolon*	3	H	Med	TR	1TMMM	Sc	Mf	Mez	Ap		12					
	Oleaceae																
33	*Fraxinus excelsior* L.	6	Ph	Eur-Med	TR	1TMMM	He	Mf	Mez	Av			10,11		V	V	V
34	*Fraxinus ornus* L.	6	Ph	SubMed	TR	1TMMM	He	Mf	Xefl	Av	1,2,3,4	5,6,7,8	9,10,11,1213, 14	15,16,17 18, 19	V	V	V
35	*Syringa vulgaris* L.	5	Ph	Carp-Bal	TR	1TMMM	He	Xm	Mez	Ap			10,11,12			V	V
	Polygonaceae																
36	*Bistorta major* Gray.	3	H	Eur-As	QR	1MSBC	Sh	Mf	Mic	Ap		7		15,18,19		V	
37	*Rumex acetosa* L.	3	H	Boreal	TR	IIMSBC	He	Mf	Mez	At			13,14	15,16,1819		V	
38	*Rumex crispus* L.	3	H	Boreal	TR	1TNCC	Sh	Mf	Mez		3	6,7	9,11,14	15,16,1819		V	
	Ranunculaceae																
39	*Adonis vernalis* L.	3	H	Eur-Sib	QR	1TNCC	He	Xm	Mez	Av			10			V	V
40	*Caltha palustris* L.	3	H	Kos	TR	1MSBC	Sh	Hm	Mez	Av	4					V	V
41	*Clematis vitalba* L.	5	Ph	Eur	TR	IITMMM	He	Mf	Mez	Ap	1,3,4	5,6,7,8	9,10,11,1213,14	15,16,1718, 19		V	
42	*Isopyrum thalictroides* L.	3	G	Eur	TR	1TMMM	Sc	Mf	Mez	Av	1,2,4		9,11,12			V	
43	*Thalictrum minus* L.	3	H	Eur-Sib	TR	1TSCC	He	Xm	Mez	Av		10				V	
	Rosaceae																
44	*Sorbus aria* (L.) Grantz	5,6	Ph	Eur	TR	1TMMM	Sh	Xm	Mez	Av	2	5	12		V	V	
45	*Rosa gallica* L.	5	Ph	Eur-Med	TR	IITMMM	He	Xm	Mez	Ap		10					V
	Salicaceae																

№	Taxa	Biological types	Life forms	Floristic elements	Origin	Phytogeographical elements	Ecological groups			Synantropic groups	Part of the mountain with transects (No)				Uses		
							Light	Soil humidity	Temperature		Part 1	Part 2	Part 3	Part 4	Forestry	Non wood forest products	Decorative
46	*Populus alba* L.	6	Ph	Eur-As	TR	1TSCC	He	Mf	Mez	Av			11	18,19	V	V	
47	*Populus canescens* (Aiton) Sm.	6	Ph	Eur-Med	TR	2TMMM	He	Mf	Mez	Av	2	6,7	11		V	V	V
48	*Populus nigra* L.	6	Ph	Eur-As	TR	1TMMM	He	Mf	Mez	Av			11		V	V	V
49	*Populus tremula* L.	6	Ph	SubBoreal	TR	1MSBC	He	Mf	Mez	Av	1,2,3,4	5,6,7,8	9,10,11,1213,14	15,16,1718, 19	V	V	V
50	*Salix alba* L.	6	Ph	Eur-As	TR	1MSBC	He	Hm	Mez	At		7	11,14		V	V	V
51	*Salix caprea* L.	6	Ph	SubBoreal	TR	1MSBC	He	Hm	Mez	Av		8		19		V	V
52	*Salix cinerea* L.	6	Ph	Eur-As	TR	1MSBC	He	Hm	Mez	Av		7	11		V	V	V
53	*Salix fragilis* L.	6	Ph	Eur-As	TR	1MSBC	He	Mf	Mez	At			11		V	V	V
54	*Salix purpurea* L.	6	Ph	Eur-Med-Cas	TR	1MSBC	He	Mf	Mez	Av			11		V	V	V
	Tiliaceae																
55	*Tilia tomentosa* Moench	6	Ph	Eur-Med	TR	1TMMM	Sh	Xm	Mez	Av	1,2,4	5	9,10,11,1213	17,19	V	V	V
	Ulmaceae															V	V
56	*Ulmus minor* L.	6	Ph	Eur-Med	TR	2TMC	Sh	Mf	Mez	Av	4		10	17	V	V	
Liliopsida																	
	Dioscoreaceae																
57	*Tamus communis* L.	3	G	SubMed	TR	1TMC	Sh	Mf	Mez	Ap			12			V	
	Iridaceae																
58	*Iris pumilla* L.	3	G	SubMed	QR	1TNCC	He	Xe	Mez	Av				15			V
	Liliaceae																

№	Taxa	Biological types	Life forms	Floristic elements	Origin	Phytogeographical elements	Ecological groups			Synantropic groups	Part of the mountain with transects (No)				Uses		
							Light	Soil humidity	Temperature		Part 1	Part 2	Part 3	Part 4	Forestry	Non wood forest products	Decorative
59	*Erythronum dens-canis* L.	3	G	Med	TR	1TMMM	Sh	Mx	Mez	Av	4						V
60	*Veratrum album* L. subsp. *lobelianum* (Bernh.) Rchb.	3	G	Eur-As	QR	1MSBC	He	Mf	Mic	Av	2		11	15,18		V	
61	*Polygonatum odoratum* (Mill.) Druce	3	G	Eur-Sib	TR	1MSBC	Sh	Xm	Mez	Av	3		10,12			V	V

Table 2. Comparison of the number of relicts between Lozenska Mt. and other mountains in the western part of the country.

Mountains in Western Bulgaria	Distance from the capital (km)	Max. Altitude (m)	Area (km^2)	Number of Tertiary relicts	Number of Quaternary relicts	Total Number of relicts	Number of species in the Mt's flora	% from the Mt's. flora	Source
Lozenska Mt.	15	1190.2	80	57	5	61	823	7.4	Glogov (2017)
Golo bardo	40	1147.0	100	23	2	25	724	3.5	Apostolova-Stoyanova, Stoyanov (2009)
Chepan Mt.	40	1205.6	25	23	3	26	784	3.3	Zahariev (2017)
Zemenska Mt.	70	1295.0	110	26	1	27	1354	2	Asenov, (2015)

Table 3. Taxonomical structure of the relict plants found on the territory of Lozenska Mt.

Part of the Mt.	Rang	Eqiusetophyta Number/%	Pteridiophyta Number/%	Pinophyta Number/%	Magnoliphyta		Total
					Magnoliopsida Number/%	Liliopsida Number/%	
Part 1	family	0(0.0%)	1(4.0%)	2(8.0%)	21(84.0%)	1(4.0%)	25(100.0%)
	genus	0(0.0%)	1(3.1%)	3(9.4%)	25(78.1%)	3(9.4%)	32(100.0%)
	species	0(0.0%)	1(2.6%)	5(13.2%)	29(76.3%)	3(7.9%)	38(100.0%)
Part 2	family	0(0.0%)	1(4.5%)	2(9.1%)	19(86.4%)	0(0.0%)	22(100.0%)
	genus	0(0.0%)	1(4.2%)	2(8.3%)	21(87.5%)	0(0.0%)	24(100.0%)
	species	0(0.0%)	1(3.1%)	3(9.4%)	28(87.5%	0(0.0%)	32(100.0%)
Part 3	family	0(0.0%)	1(3.8%)	2(7.7%)	21(80.8%)	2(7.7%)	26(100.0%)
	genus	0(0.0%)	1(3.0%)	2(6.1%)	28(84.8%)	2(6.1%)	33(100.0%)
	species	0(0.0%)	1(2.2%)	3(6.7%)	38(84.4%)	3(6.7%)	45(100.0%)
Part 4	family	1(4.2%)	1(4.2%)	2(8.3%)	18(75.0%)	2(8.3%)	24(100.0%)
	genus	1(3.7%)	1(3.7%)	2(7.4%)	21(77.8%)	2(7.4%)	27(100.0%)
	species	1(2.8%)	1(2.8%)	3(5.6%)	25(80.6%)	2(8.3%)	32(100.0%)
Whole territory	family	1(2.9%)	1(2.9%)	2(5.7%)	28(80.9%)	3(8.6%)	35(100.0%)
	genus	1(2.1%)	1(2.1%)	2(4.2%)	39(81.3%)	5(10.4%)	48(100.0%)
	species	1(1.6%)	1(1.6%)	5(8.2%)	49(80.3%)	5(8.2%)	61(100.0%)

parts. 14.8% of the species were only distributed in Part 3; 11.5% occurred only in Part 1; 4.9% - in Part 2 and Part 4 each. The distribution of the species according to their biological type and life forms is shown on Figures 3 and 4. The phanerophytes (dominated by the trees) prevailed with more than 60%, followed by the hemicryp-

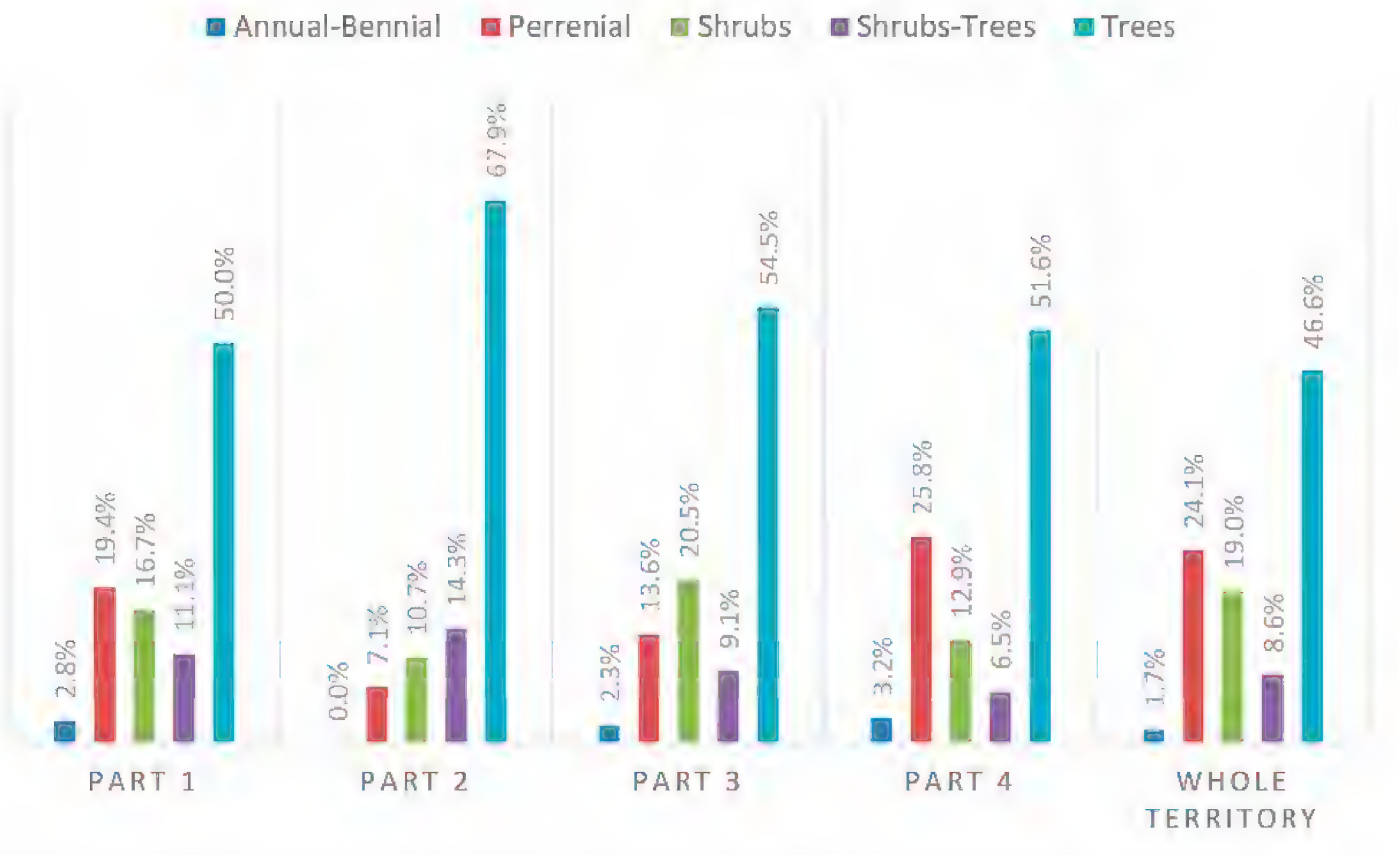

Figure 2. Biological types of the relict species on the territory of the Lozenska Mt.

tophytes (16.4%) and geophytes (13.1%) in each of the studied territories. Among the phanerophytes with the highest participation were the trees (37.7%). No species with a two-year life cycle have been identified.

The distribution of the relicts on the territory of Lozenska Mt. as determined by the floristic elements (Table 4) showed the highest contribution of elements with Eurasian and sub-Mediterranean origin. The European and Eurasian types had the largest variety of floristic elements (with three species each).

The analysis of the phytogeographic elements (Table 5) suggested two predominant influences on their distribution on the territory of the Lozenska Mt.: from mountainous (41.9%) and silvoboreal (40.3%) centres. The percentage of stationary to mobile and secondary elements was 84.0: 6.4: 9.6.

The ratio of relicts in the phytogeographic spectrum corresponded completely to their distribution according to the thermal factor (Fig. 4). The predominant group (86.9%) was the group of the mesotherms or plants of temperate regions. The microtherms, the species of moderately cold areas, and the xerophylls, typical and common in the warm and dry climate, were registered with much lower participation: 6.6% and 4.9%, respectively.

Concerning the other two major ecological groups based on preferences for different light regimes and soil moisture, the results indicated a predominance of heliophytes and a mesophyte group (Fig. 5 and 6) in the studied flora.

The presence of anthropophytes (Fig. 7) among the Lozenska Mt. relicts was limited. Most of them were distributed in the eastern parts of the mountain.

The benefits and potential uses of the relicts were conditionally divided into three major groups: forestry uses, which includde both the forestry benefits of the

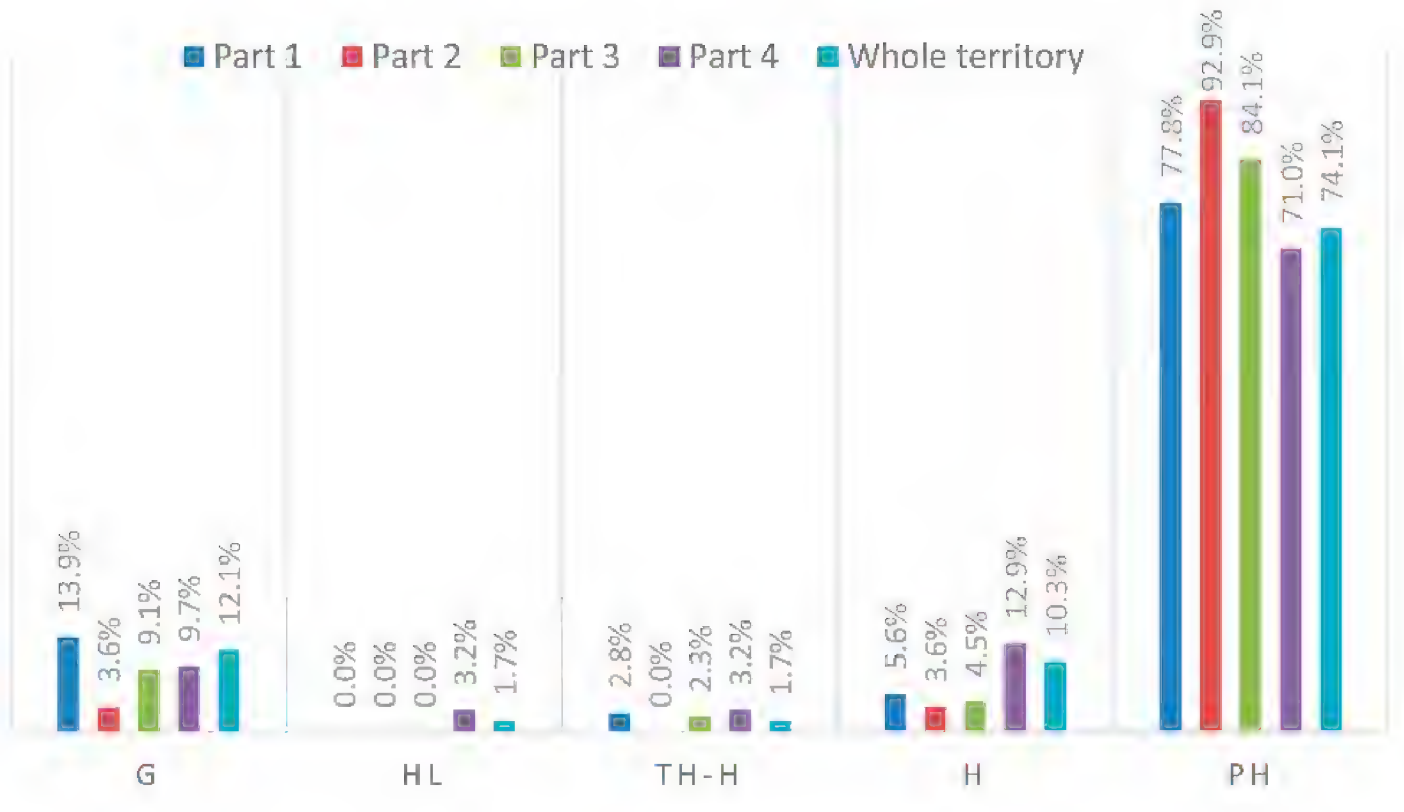

Figure 3. Biological spectrum of the relict species on the territory of the Lozenska Mt.

Table 4. Floristic elements.

Floristic elements	Abbreviation	Part 1 (%)	Part 2 (%)	Part 3 (%)	Part 4 (%)	Whole Mt. (%)
1. EUROPEAN TYPE	EUR	28.9	25	28.3	21.9	22.6
1.1. European typical	Eur	7.9	6.3	6.5	3.1	4.8
1.2. European-Mediterranean	Eur-Med	15.8	12.5	17.4	12.5	14.5
1.3. European-SubMediterranean	Eur-SubMed	5.3	6.3	4.3	6.3	3.2
2. EUROPEAN-ASIAN TYPE	EUR-AS	18.4	21.9	28.3	28.1	29
2.1.European-Asian	Eur-As	10.5	15.6	17.4	18.8	17.7
2.2. European-Mediterranean-CentralAsian	Eur-Med-CAs	0.0	0.0	2.2	0.0	1.6
2.4. European-Syberian	Eur-Sib	7.9	6.3	8.7	9.4	9.7
3. SUBMEDITERRANEAN TYPE	SUBMED	23.7	21.9	17.4	21.9	17.7
3.1.Submediterranean type	SubMed	23.7	21.9	17.4	21.9	17.7
4. MEDITERRANEAN TYPE	MED	5.3	9.4	6.5	3.1	8.1
4.1. Mediterranean typical	Med	2.6	3.1	0.0	0.0	3.2
4.2.Mediterranean-Asiatic	Med-As	0.0	0.0	2.2	0.0	1.6
4.3.Mediterranean-CentralAsiatic	Med-CAs	2.6	6.3	4.3	3.1	3.2
5. BOREAL TYPE	BOREAL	15.8	15.6	10.9	21.9	14.5
5.1. Boreal typical	Boreal	7.9	3.1	4.3	9.4	8.1
5.2. Subboreal	SubBoreal	7.9	12.5	6.5	12.5	6.5
6. BALCAN SUBENDEMIC TYPE	SUBBAL	0.0	0.0	2.2	0.0	1.6
8.5. Carpathian-Balcan	Carp-Bal	0.0	0.0	2.2	0.0	1.6
7. COSMOPOLITAN TYPE	KOS	7.9	6.3	4.3	3.1	4.8
TOTAL (%)		100.0	100.0	100.0	100.0	100.0

Table 5. Phytogeographic elements.

Phytogeographic element	Part 1 (%)	Part 2 (%)	Part 3 (%)	Part 4 (%)	Whole Mt.(%)
1TMMM	42.1	40.6	41.3	34.4	35.5
2TMMM	7.9	6.3	4.3	3.1	4.8
IITMMM	0	3.1	0.0	0.0	1.6
1 MSBC	36.8	37.5	32.6	37.5	38.7
II MSBC	0.0	0.0	2.2	3.1	1.6
1TNCC	5.3	6.3	6.5	9.4	6.5
2TNCC	0.0	0.0	0.0	3.1	1.6
1TSCC	0.0	0.0	2.2	3.1	1.6
IITSCC	5.3	6.3	6.5	3.1	4.8
1TMC	2.6	0.0	2.2	3.1	1.6
IITMC	2.6	3.1	2.2	3.1	1.6
Total (%)	100.0	100.0	100.0	100.0	100.0

species (forestry, soil protection, anti-erosion), as well as the production of wood. This group included edificatory tree species in forest communities and a large proportion of accessorial elements (36.1% of all relicts of the mountain). The second group (non-wood resources) generally included plants used for their medicinal,

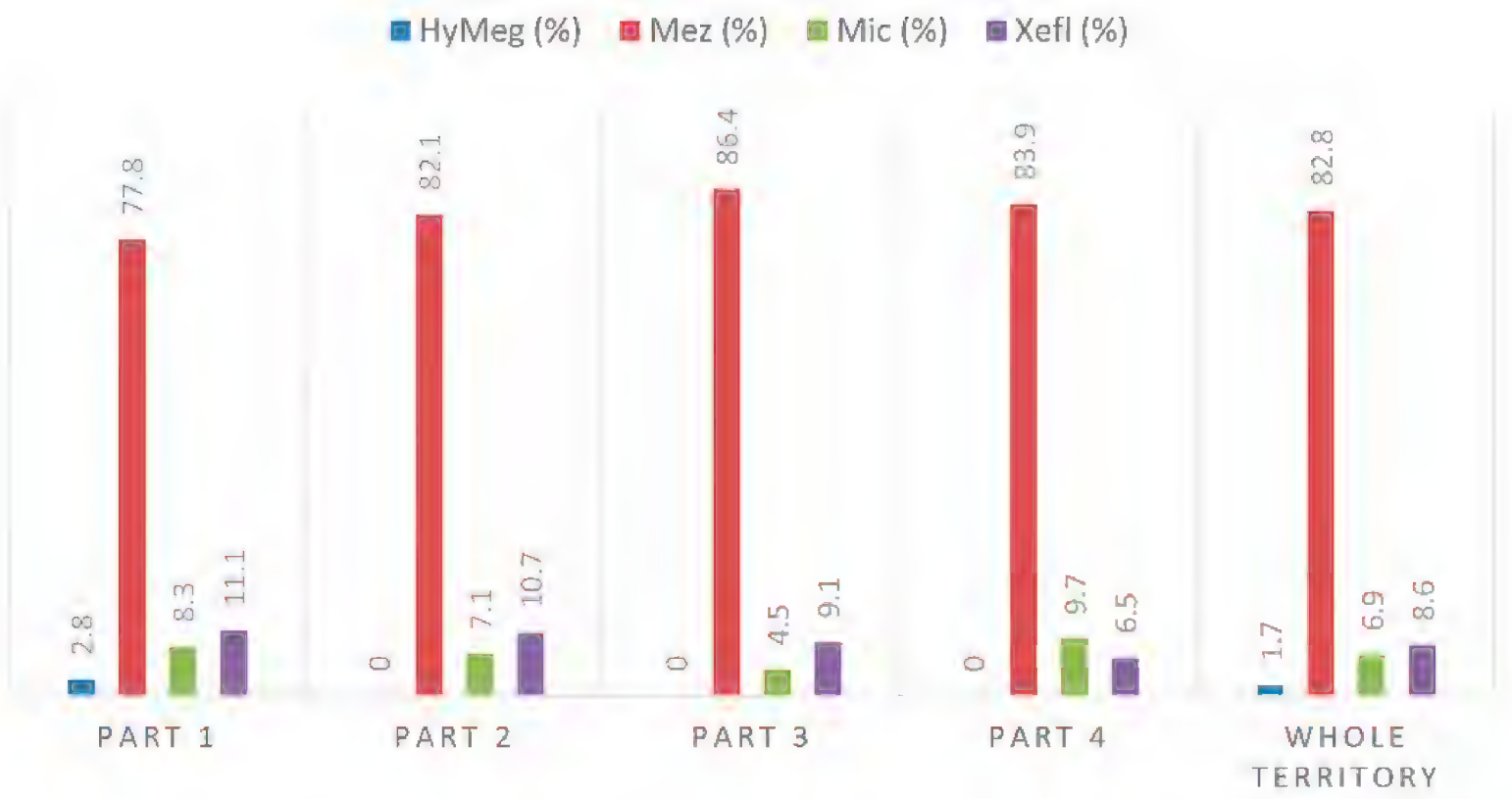

Figure 4. Distribution of ecological groups of species according to the temperature.

Figure 5. Distribution of ecological groups of species according to their preferences for different light regimes.

honey-bearing, nutritional properties (resin extraction, terpenes, alkaloids, cosmetic oils, etc.). This group comprised the largest number of species (88.5% of all relicts) and included 59.0% of all trees and shrubs and 29.5% of grass species identified during the study. The last group composed of plants with ornamental value

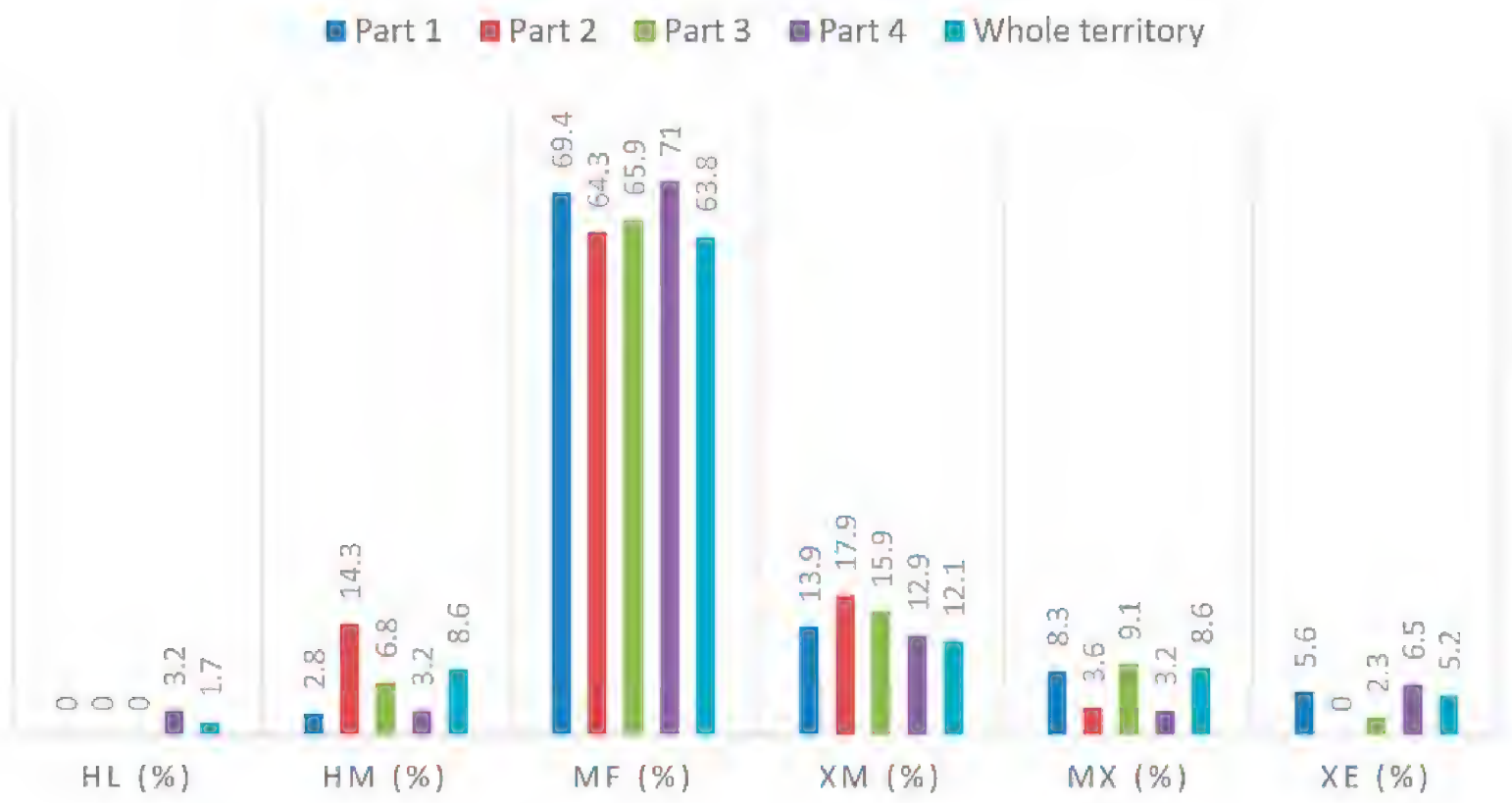

Figure 6. Distribution of ecological groups of species according to the soil moisture.

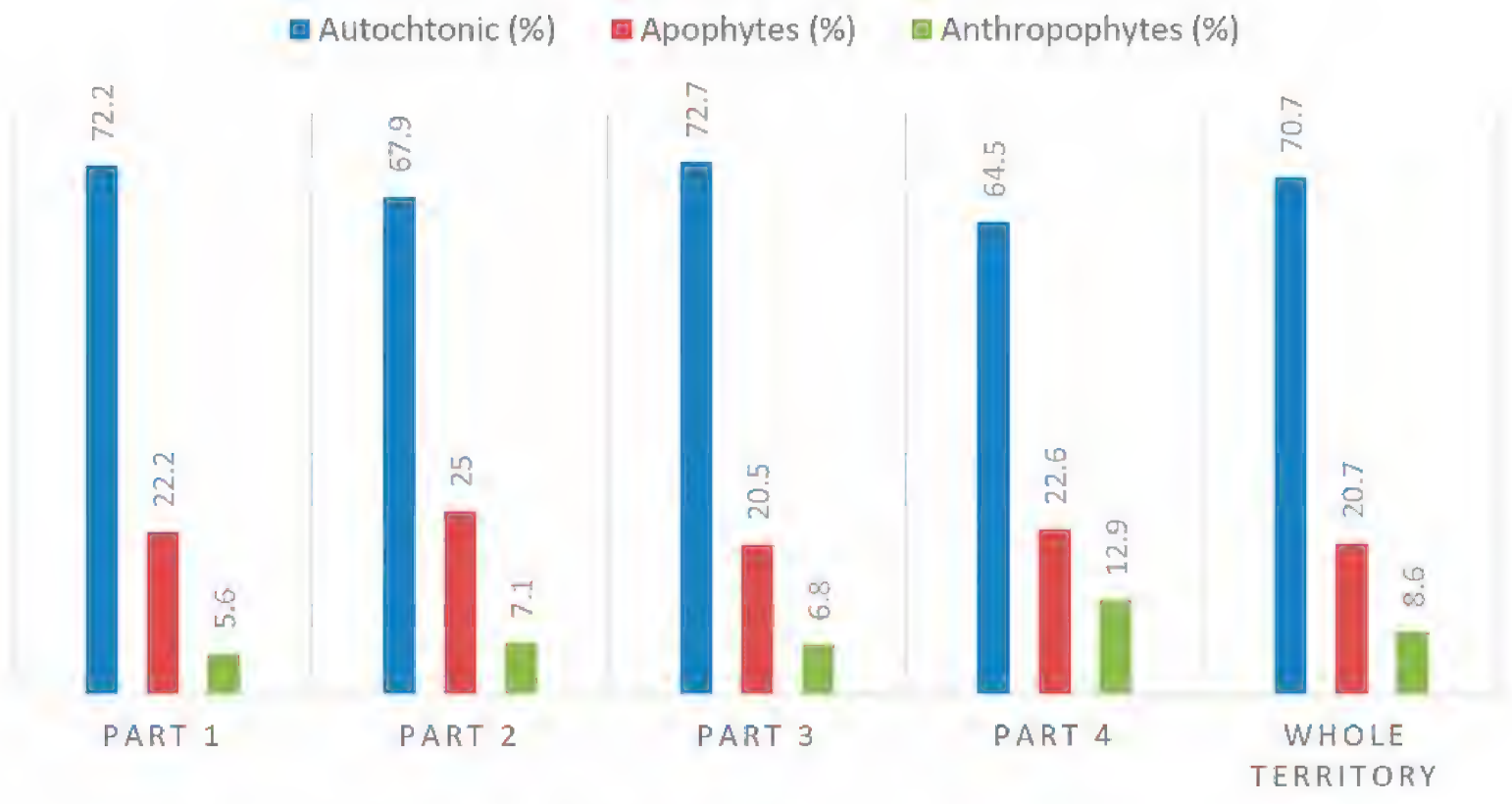

Figure 7. Distribution of synanthropic groups.

(decorative use) and was represented by 54.1% of the species. This group included 44.2% trees and shrubs and 9.9% grasses of all the species. 27.9% of the relicts were species included in the three economical benefit groups; 6.6% were classified as having both forestry and non-wood uses only; 18.0% had decorative and non-wood uses only and 0.0% had forestry and decorative uses only.

Discussion

The taxonomical structure of the relict composition on the territory of the Lozenska Mt. is close to that in the Bulgarian relict flora. According to Zahariev (2016), Salicaceae is the third family in our flora that is most abundant in relict species and *Salix* is the leading genus among the genera in Bulgaria in terms of the share of relict species.

The distribution of relicts in different parts of the mountain fully corresponded to the results from the floristic study of Lozenska Mt. by Glogov (2017), where the greatest taxonomic diversity was observed in its south-west part (Part 3) and the lowest was recorded in the north-east part (Part 2) of the mountain. The south-west part was characterised by a wide variety of ecological niches, including carbonate terrains. Most of the endemics, sub endemics, rare and medicinal plants were found there during studies of the entire flora of the mountain. The record of the relict subendemic *Syringa vulgaris,* found only in this section, confirms the connections of the mountain in view of its floristic similarity and species distribution with the mountains of the Western Balkans, the Apennines and the Carpathians, whose influence through the Western Stara Planina and Vitosha Mountains reaches the west parts of the Lozenska Mt. The north-east part is the most anthropogenically influenced because of the coal extraction in the Chukurovo mine and for this reason on its territory the natural biodiversity is the lowest and the presence of invasive alien species is significant. Evidence that the Lozenska Mt. is a site with overlapping areas of relict species from different phytogeographic centres is found in its north-west part (Title 1). Only there are identified two relicts of different origins and pathways of irradiation. The cade juniper (*Juniperus oxycedrus*) is a sub-Mediterranean species and stationary thermophyte from the Mediterranean centre. This species is among the few representatives of this phytogeographic centre that is expanding into the mountain belt of Bulgaria. The established locality in the north part of the mountain is more a remnant of the former range of the cade juniper than an evidence of warming and xerophytic processes. Similar fragmentary habitats of the species have been established by Velchev et al. (1968) on the territory of the Ihtimanska and Sashtinska Sredna Gora Mountain. Another characteristic species found only in the north-east part of the Lozenska Mt. is the bilberry (*Vaccinium myrtillus*), which is a boreal element belonging to the Silvoboreal Phytogeographical centre. Adjacent to the west parts of Lozenska Mt. are Plana Mt. (1337.4 m a.s.l.) and Vitosha Mt. (2290 m a.s.l.), where the bilberry is a characteristic species of *Vaccinio-Piceetea* Br-Bl. communities together with other relict species, such as *Picea abies* and *Pinus silvestris*. Its share is limited on the territory of the Lozenska Mt., since this species benefits from conifer forests and declines with an increase of broad-leaved tree species in the canopy. (Höcke, 2015).

The high percentage of relict trees and shrubs, as well as geophytes among the life forms and biological types, could be explained by the forest type of vegetation covering more than 75.0% of the territory of the Lozenska Mt. and with the active

presence of second layer of shrubs and small trees in the natural forests and artificial stands.

The two largest groups of floristic elements established on the territory of the mountain with equal participation, Eurasian and sub-Mediterranean, are also prevalent in the group of the Tertiary relicts in the country (Zahariev, 2017). Second, in terms of participation, are the elements of the European group, which in principle are the most numerous representatives in the flora of the mountain and largely determine its character (Glogov, 2017). There are no relict endemics on the territory of the Lozenska Mountain, only one Balkan subendemic *Syringa vulgaris* has been found. *Campanula lingulata* Waldst. & Kit. is also present on the territory of the mountain and is classified as an Apenine-Balkan subendemic within the group of the Tertiary relicts. In the present study, the species were determined according to Delipavlov, Cheshmedzhiev (2003), but these taxa has been considered by contemporary authors, such as Škondrić at al. (2014), as a complex of species with high adaptability, plasticity and/or heterogeneity with a considerable morphological polymorphism. This has triggered delineation of several taxa within this complex, overall resulting in a plethora of "taxonomic" synonyms for *C. lingulata*. For this reason, the species is not included by the authors in the final list of relicts on the territory of the Lozenska Mt.

The predominance of mountainous and silvoboreal relict elements could be explained from the point of view of the physicogeographical characteristics of the studied area. In addition, the two groups are close in terms of their distribution and they comprise the majority of the species constituting the phanerophytic element in the plant cover (Stefanoff, 1943). The predominant number of stationary elements among the relicts is normal, given that they represent the most permanent and characteristic element for those vegetation types that have been least affected by human activity and by the processes of secondary replacement (Stefanoff, 1943). Most of the relicts extend their primary habitats in Europe and Asia. They are characterised by a stationary regime, which determines the gradual narrowing of their ranges under the influence of changing environmental factors. The strong sub-Mediterranean influence on the relict flora of the Lozenska Mt. is not caused by mobile elements or those with "secondary areal" (Stefanoff, 1943), neither by stationary species from the mountainous centre which ranges include thermophytic species. The Eurasian origin and sub-Meditherranean influence on the flora is evidence of the smooth transition from Paleocenoses to modern vegetation types. An additional argument for this process is the high proportion of mesotherms from the two mountain and silvoboreal centres and the low participation of thermophytes and microtherms in the distribution of ecological groups according to the temperature factor.

These results correspond with the statement of Stefanoff (1930) that "the evergreen insular and mixed deciduous vegetation of the temperate regions are related to each other by a number of transitional forms and states - the gradual narrowing of the evergreen xeromorphic element and its replacement by hygromorphic species". Through the Tertiary, the main vegetation type of the mountain belonged to

moderately warm evergreen deciduous forests or to the similar type referred to as macrophilic, whose most significant characteristic is its transitional character: from typical hygrophytic laurel forests to mixed mesohygrophytic and mesophytic forest communities. (Palamarev, 1989b). Evidence of this process is the presence of the most relict edificators of mesophyte and xeromesophyte communities. Relict theory has explanatory power to account for patterns of endemism (Cronk, 1992). The lack of endemic species and the low participation of sub endemics in relicts are an indirect evidence of the lack of endemic centres of origin due to the low altitude and insufficient geographical isolation of the studied area.

The distribution of the ecological groups, according to the light and soil moisture, is similar to the one found for the mountain flora by Glogov, Delkov (2016). In the mesophyte group, typical mesophytes were predominant, while in the xerophytic group, mesoxerophytes were dominant, while typical xerophytes were recorded as an exception.

The distribution of the majority of mesoxyrophytic species is on Chromic Luvisols in the xerothermic oak belt. This belt covers the plain sites and slopes, which typically incline up to 10° and reach up to 760 m a.s.l., for slopes facing south the altitude reaches 950 m a.s.l. This belt includes oak forests with *Quercus frainetto* Ten., Q. cerris L. and *Q. pubescens* Willd. The mesophyte group is located predominantly on the larger area of Dystric-Eutric Cambisols in the mesophytic oak and hornbeam belt. That is in agreement with soil types and their characteristics.

The mesophitic oak belt of the Lozenska Mt. consists of communities of *Quercus dalechampii* Ten. It covers the higher and steeper (more than 15°) parts of the slopes. For the slopes facing north,it is usually above 760 m a.s.l, while for the slopes facing south it is 950 m a.s.l. The hornbeam (*CarPinus betulus* L.) belt has two sub-belts: the typical hornbeam sub-belt (between 850 and 950 m a.s.l.) and the beech sub-belt (between 900-1100 m a.s.l). Part of the mesophytes, along with hygromezophytes, are distributed on Alluvial Fluvisols, which occur at valley extensions formed on riverbeds throughout the Lozenska Mt.

The ratio between them, apophytes and autochthones (8.2%:23.0%:69.0%) differed from the one established for the whole flora of the mountain (33.3%:27.5%:39.2%; see Glogov, 2017). The predominant number of autochthonous species proves the presence of the native forest vegetation of the mountain and the adaptability of its edificatory species to the environmental conditions. The majority of the apophytes are shrub species that participate as an undergrowth in indigenous communities and after succession form secondary phytocenoses. They are species of high plasticity and part of their environmental strategy is the use of the human factor. Among the few anthropophytes found in the relict flora of the mountain, all without exception are species with secondary expanded range and their survival and distribution is related to the development of human cultural and economic activities.

More than half of the relicts (about 61.3%) are diagnostic of certain NATURA 2000 habitats. Few of them are diagnostic of one type of habitat within the study site, e.g. *Syringa vulgaris* and *Rosa gallica* are diagnostic species of habitat 40A0

Peri-pannonian subcontinental shrubs, which is included in the Red Data Book of the Natural Habitats (Biserkov et al., 2015). Due to their wider ecological amplitude, most of the relict species found in the mountain range are diagnostic of more than one habitat type. For example, *CarPinus betulus* is diagnostic for habitats 9150 Medio-European limestone beech forests of the Cephalanthero-Fagion and 9170 Galio-Carpinetum oak-hornbeam forests; *Quercus cerris* is diagnostic of the 91MO Pannonian-Balkanic Turkey oak-sessile oak forests and also for habitats with code 9150.

In spite of the numerous benefits, which imply a high level of exploitation of the resources of these species, only two of the relicts have a conservation status. *Salix caprea* and *Polygonatum odoratum* have been included in the Biodiersity Act (2002). Many of the relicts are protected by the Biodiversity Act (2002) because they are diagnostic species of NATURA 2000 habitats, as well as those included in the Red Data Book (Biserkov et al., 2015), such as the above mentioned habitat 40A0 which is in category "Endangered".

Along with this category are the habitats 9130 Neutrophilic common beech forests (Asperulo-Fagetum beech forests) with diagnostic species Asarum europaeum and *Lamiastrum galeobdolon* and 91M0 Balkan-Pannonian Turkey oak-sessile oak forests (with diagnostic relict species *Acer tataricum*). Part of the relicts are diagnostic of habitat 9170 within the category "Near Threatened ". These include tree species, such as *Acer platanoides* and early spring geophytes, such as *Isopyrum thalictroides* and *Erythronum dens-canis* etc.

A large number of species (57.0%) fall under the provisions of the Medicinal Plants Act (2000). Most of the objectives mentioned in the General Provisions of the Forestry Act (2011) relate directly or indirectly to the protection of relicts and their habitats. Such objectives are "protecting and increasing the area of forests and maintaining and improving their condition; guaranteeing and maintaining the ecosystem, social and economic functions of forest areas and guaranteeing and increasing the production of timber and non-timber forest products through the sustainable management of forest areas".

Conclusions

On the territory of the Lozenska Mountain there is a significant number of relict species for the mountain's area and altitude, which are evidence of the preserved autochthony of its flora and of the primary types of vegetation.

The taxonomic structure of the relict flora of the mountain is similar to that of the whole country. A greater number of relicts are observed in the western parts of the mountain, where there is a greater variety of ecological niches, more than in the east, where the anthropogenic load is higher.

The origin of the relicts is mainly Euro-Asian and submediterranean, with mountainous and silvoboreal phytogeographic centers having the strongest influence on their distribution routes.

The relicts of the mountain are connected with the vegetative types of forest vegetation – a characteristic of the thermal zone. Among them, in the biological-ecological aspect, trees and shrubs, heliophytes, mesophytes and mesotherms predominate.

Each of the studied species is a plant with economic benefits, many of which play an indispensable role as forest growers in forest belts and their relict value is an important additional prerequisite for their sustainable management.

Most of the relicts fall under restrictive regimes as a valuable plants or species connected with the important habitats form NATURA 2000.

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